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MARKET QUALITY OF ASPARAGUS—

Effects of Maturity at Harvest and of High Carbon Dioxide Atmospheres During Simulated Transit

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Contents

	Page
Summary	3
Background	3
Methods	4
Results	4
Effect of CO_2 on bacterial soft rot	4
Constant high CO_2 for 24 hours	4
Variable CO_2 level during holding	5
Effect of maturity of spears on bacterial soft rot	6
Discussion and conclusions	7

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MARKET QUALITY OF ASPARAGUS—

Effects of Maturity at Harvest, and of High Carbon Dioxide Atmospheres During Simulated Transit

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SUMMARY

Exposing harvested asparagus spears to controlled atmospheres containing 20 percent carbon dioxide (CO_2) for 24 hours effectively reduced the incidence of bacterial soft rot at the butt end during subsequent holding of the spears in air (normal atmosphere) for about 1 week at 36°, 41°, or 50° F. An initially high (20 percent) but gradually decreasing concentration of CO_2 reduced soft rot at the butt end of spears in a simulated air transit test of 4 days at 59°. Neither treatment, however, was effective in reducing soft rot at the tips.

Bacterial soft rot at the tips of spears was significantly lower in less mature tight tips than in more mature loose or feathered tips. Culling spears with loose tips before shipment would reduce market losses in this crop.

BACKGROUND

Bacterial soft rot, a major market disease of asparagus, can be reduced when the spears are held in an atmosphere enriched with carbon dioxide (CO_2).[2] Generally, a continuous application of 5 to 10 percent CO_2 significantly reduced soft rot at the tip and butt ends of spears during 1 week's storage, without causing injury. Potential difficulties, however, in supplying a controlled amount of CO_2 during transcontinental surface or air shipments indicated the need for alternative ways to gain the benefits of CO_2, while avoiding CO_2 injury. In this study, exposing the spears briefly to a high initial CO_2 concentration was tested as a possible alternative. The relation between the maturity of the asparagus tips at harvest and the occurrence of soft rot during simulated marketing was also investigated.

[1] Stationed at Fresno, Calif. 93727.

[2] Lipton, W. J. post-harvest response of asparagus spears to high carbon dioxide and low oxygen atmospheres. Amer. Soc. Hort. Sci. Proc. 86: 347–356, illus. 1965.

METHODS

The procedures given below apply to all the experiments reported; details for specific tests will be given in the relevant section of the results.

Asparagus for the test lots was grown in the San Joaquin Delta, the Salinas Valley, or the southern San Joaquin Valley of California during 1962 through 1967. Samples of the green asparagus arrived at the Fresno laboratory within 3 hours following harvest, and they usually were placed under the desired storage conditions on the same day. When a test could not be set up on the day of harvest, the spears were held overnight at 36° F. and at high humidity.

During the experiments, controlled atmospheres were maintained in airtight glass jars or stainless steel chambers. The containers were flushed with CO_2 from a high-pressure cylinder to obtain the desired atmospheres. In all experiments, oxygen (O_2) remained at noninjurious levels. CO_2 and O_2 concentrations were monitored with an Orsat-type gas analyzer. The sides of the jars were lined with wet paper towels to maintain a high relative humidity, but in the chambers, the spears were set on wet fiber or sphagnum moss pads.

After storage, the spears were examined for bacterial soft rot, physiological deterioration, and high CO_2 injury. Relevant data on the incidence of these disorders were tested by analysis of variance for split plots. The data were transformed to natural logarithms for analysis; their antilogarithms are presented in this report.

The flavor of some of the treated and subsequently cooked asparagus was evaluated, and the resultant data were analyzed using Kendall's Coefficient of Concordance for incomplete block designs.[3]

RESULTS

EFFECT OF CO_2 ON BACTERIAL SOFT ROT

Constant High CO_2 for 24 Hours

Asparagus was exposed to high CO_2 levels for 24 hours and then placed in normal air to check the possibility of reducing soft rot by this procedure.

Spears held loose in jars.—Samples of about 40 spears (1,000 grams) were held in glass jars for 7 or 8 days at 36°, 41°, and 50° F. Atmospheres were 0 (air), 10, 20, 30, or 50 percent CO_2 for the initial 24 hours. The CO_2 concentration of the CO_2-treated lots increased about 2 to 5 percent during the 24-hour period. The O_2 concentration was above 8 percent during this treatment except in the sample held in 50 percent CO_2, where the O_2 dropped to between 4 and 5 percent. After 24 hours, the asparagus was held in air at the same temperatures. The asparagus was examined for decay after the 7- or 8-day interval at the temperatures given, and after 2 additional days at 59°.

Soft rot of the butts was consistently less in the spears held 24 hours in 20, 30, or 50 percent CO_2 than in spears held in air throughout after either holding period. Ten percent CO_2 was somewhat less effective in reducing rot than the higher concentrations (table 1). In contrast, CO_2 was ineffective in reducing soft rot of the tips, regardless of concentration, either at the first examination, when very little decay was present, or at the second examination, when it was widespread.

Typical CO_2 injury (see reference listed in footnote 2) occurred in lots held in 30 and 50 percent CO_2 at 50° F., but not in the lots held at 36° or 41°. Although 50 percent CO_2 caused no injury at the lower temperatures, this concentration was not tested further because of the chance of injury.

Spears packed commercially.—The range of CO_2 concentrations that effectively reduced decay without causing injury was then tested on asparagus packed commercially in half-size containers. The packed crates or waxed cartons of asparagus were placed into chambers at 36° or 41° F. and held for 24 hours in 0, 10, 20, or 30 percent CO_2, and then for 5 subsequent days in air. After this holding period, half the sample (60 to 100 spears, depending upon the test) was examined for decay, and the other half after being held an additional 3 days at 59°.

In this series of four tests, soft rot was less prevalent than in the tests where the spears were held loose in jars, but exposing the spears to CO_2 still

[3] MAXWELL, A. E. ANALYZING QUALITATIVE DATA. 163 pp., illus. 1961. John Wiley and Sons, N.Y.

TABLE 1.—*Incidence of soft rot at butt end of asparagus held 24 hours in various concentrations of CO_2 and then stored in air*

Percent of CO_2	Spears showing soft rot [1]		
	Held loose in jars at 36°, 41°, or 50° F.[2]		Packed commercially and held for 1 week at 36°, or 41° plus 3 days at 59° [3]
	For 1 week only	For 1 week plus 2 days at 59°	
	Percent	*Percent*	*Percent*
0	13.6 a	41.5 a	3.9 a
10	6.4 b	22.6 ab	2.2 b
20	2.6 c	11.7 bc	1.6 c
30	1.5 d	12.5 bc	1.1 c
50	.8 d	7.4 c	

[1] Means in column having no letter in common differ at the 95-percent probability level.

[2] The means represent the combined data from 4 tests each at 36°, 41°, and 50° F.

[3] The means represent the combined data for both initial storage temperatures and both examinations from 4 tests.

significantly reduced soft rot at the butts (table 1). As in the earlier tests, CO_2 did not affect soft rot at the tips. At the first examination, all lots were nearly free of decay at the tips, but after the additional 3 days at 59° F., all lots packed commercially were about equally affected.

Flavor was not impaired by the CO_2 treatment. In an informal taste test, one-half of the tasters preferred spears held in air and the other half preferred those held in 30 percent CO_2. Spears from 30 percent CO_2 were darker green than those held in air only.

Variable CO_2 Level During Holding

Although exposing the spears to constant high CO_2 for 24 hours seemed effective in reducing soft rot at the butt end, this method may not suit some situations because of the need to ventilate the system after 24 hours. Experiments were conducted, therefore, to test the efficacy of using initially high but decreasing concentrations of CO_2 to control decay in asparagus. In commercial practice, CO_2 would decrease from normal air leakage into a railcar or truck; in the laboratory, the CO_2 level was gradually reduced by passing a controlled flow of air through the storage chamber.

Simulated rail shipment.—Asparagus packed in half-crates and set on wet pads was placed into a chamber and the CO_2 content of the atmosphere was adjusted to 20 or 30 percent. The CO_2 concentration was measured 2 hours after the chambers were closed to be certain the gases were mixed; airflow at two rates—slow and fast— was started immediately thereafter. The slow rate decreased the CO_2 concentration by one-half every 19 to 22 hours, and the fast rate by one-half every 7 to 9 hours. The rates of decrease in CO_2 concentration were nearly logarithmic for the initial 24 hours, after which they slowed down (fig. 1). The same flow rates were used for the check lots held in air. The spears were held 7 days at 36° or 41° F., after which one-half were examined; the other half was held for 2 additional days at 59° before being examined.

An initial concentration of 20 percent CO_2 did not significantly reduce soft rot at either the tips

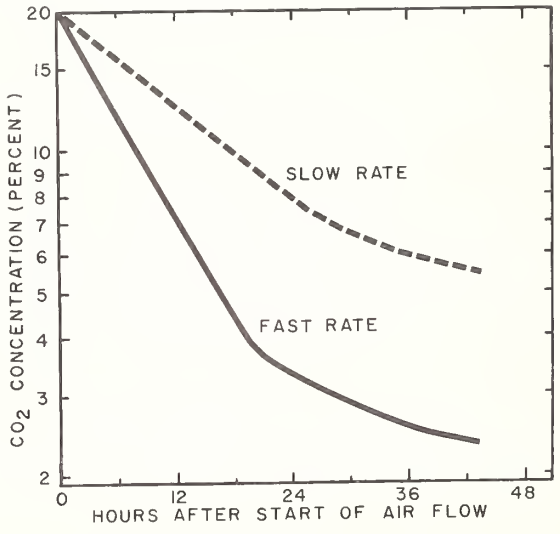

FIGURE 1.—Change in CO_2 concentration in test chambers using a slow and a fast rate of air flow. (Note that the vertical scale is logarithmic.)

or butts regardless of rate of airflow. Apparently, the bacteria were not inactivated sufficiently during the treatment to affect decay during the remainder of the 1-week storage period. Thirty percent CO_2 was used only in one test (slow-flow rate) because the persistence of a relatively high CO_2 concentration for about 50 hours resulted in a high incidence of soft rot, although no other visible injury appeared. Although these treatments did not reduce soft rot substantially, neither did they impair the flavor of the cooked spears as judged by 13 tasters in formal tests.

Simulated air shipment.—During 1966 over half a million pounds of asparagus was shipped by air from California to eastern and overseas markets. Usually there is no refrigeration during air transit, and the commodities are often exposed to temperatures near 60° F.[4] Consequently, tests were conducted to determine whether such temperatures would lead to substantial decay in asparagus during a 4-day marketing period, and whether use of CO_2 would effectively reduce decay if it occurred.

The asparagus for these five tests was prepared as noted in the preceding section and treated initially with 20 percent CO_2. Air was passed over the control lots at the same rate. However, half the spears were examined after 2 days at 59° F. in the atmosphere with decreasing CO_2, and half after 2 more days in air at 59°.

Soft rot at the butt end was reduced from 5.9 percent in the check lot to 1.7 percent in the CO_2-treated lot (the difference is significant at the 95-percent probability level). The reduction in decay was evident at both rates of airflow and at both examinations. No soft rot at the tips was found at the first examination and the prior CO_2 treatment did not significantly inhibit decay during subsequent holding of the spears in air.

EFFECT OF MATURITY OF SPEARS ON BACTERIAL SOFT ROT

In one test in this series, asparagus with loose or slightly feathered tips appeared more frequently affected by soft rot than that with tightly closed tips (fig. 2). Since spears with loose tips occur in many commercial lots, the relation between feathering of the tips and the incidence of decay was investigated systematically in all subsequent tests. The spears were segregated by feathering of tips at each examination and the number of spears having loose and tight tips with and without soft rot was recorded. The proportion of spears having loose tips ranged from almost none in some lots to 75 percent in others.

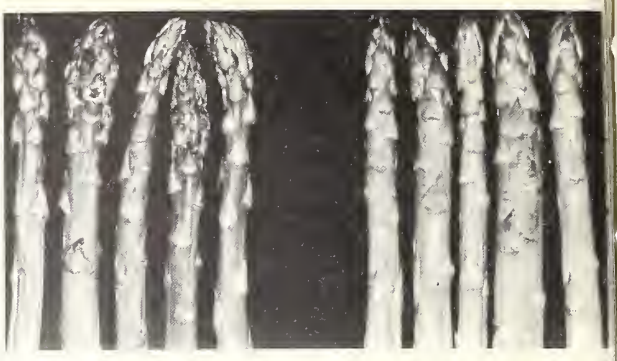

FIGURE 2.—Appearance of asparagus with loose (left) and tight (right) tips obtained from a commercial pack. After 7 days' storage at 41° F. plus 3 days at 59°, 65 percent of the spears with loose tips and 31 percent with tight tips were decayed.

The incidence of soft rot was 2 to 3 times as great in spears with loose tips as in those with tight tips (table 2). These results were not affected by any prior CO_2 treatment.

Tip condition also can affect physiological deterioration. In a test in which asparagus was held for 4 days at 59° F., deep, longitudinal depressions occurred on 6 percent of spears with loose tips, but on only 1 percent of those with tight tips.

TABLE 2.—*Incidence of soft rot in asparagus spears with tight or loose tips, 3 storage conditions*

Storage period and temperature	Percentage of asparagus spears with soft rot [1]	
	Tight tips	Loose tips
1 week at 36° or 41° F.—	*Percent*	*Percent*
Plus 2 days at 59°	5. 8	15. 6
Plus 3 days at 59°	7. 2	20. 3
4 days at 59°	4. 0	9. 0

[1] The difference in incidence between tight and loose tips are significant at the 99-percent probability level for each of the 3 storage conditions. The data for each storage condition are means of 2, 2, and 5 tests, respectively.

[4] HARVEY, J. M., COUEY, H. M., HARRIS, C. M., and PORTER, F. M. AIR TRANSPORT OF CALIFORNIA STRAWBERRIES: FACTORS AFFECTING MARKET QUALITY IN SPRING SHIPMENTS—1966. U.S. Dept. Agr. Mktg. Res. Rpt. 774, 9 pp, illus. 1966.

DISCUSSION AND CONCLUSIONS

These results indicate that exposing asparagus to about 20 percent CO_2 during the first 24 hours after harvest may be useful in reducing the incidence of soft rot at the butt end during marketing. This procedure might be applicable for shipping or for holding asparagus at processing plants during periods of oversupply. An initially high (20 percent) but gradually decreasing concentration of CO_2 was effective in reducing soft rot during a simulated air transit test (4 days at 59° F.), but not if treatment and storage (1 week) were at 36° or 41° F.

Soft rot at the tips was reduced in earlier tests by continuous application of a moderate concentration of CO_2 during storage for 1 week (see reference listed in footnote 2). In contrast, brief treatments were almost uniformly ineffective. It is not clear why CO_2 can inhibit bacterial growth at the butt but not at the tip end under these circumstances. Increase in acidity of the tissue does not seem to be involved, because after storage in 10 percent CO_2 (4 days at 50° F.) the pH of the extracted sap of the tips or butts increased 0.4 to 0.7 units. Since low, not high, pH generally inhibits bacterial growth, direct pH effects cannot be involved. Possibly the CO_2 causes a critical change in the substrate for the bacteria, which differs greatly between tips and butts. The tips are relatively high in protein and low in sugars while the butts are low in protein and high in sugars. However, the mechanism of such an interaction, if it does exist, is not clear.

While CO_2 cannot effectively reduce soft rot at the tip end under the conditions tested, soft rot at the tips can be reduced effectively simply by culling spears with loose and feathered tips. These tips not only decay more rapidly, but also are unsightly. Proper sorting would, therefore, not only improve the appearance of the pack, but would also insure a longer shelf life and a better product for the consumer.

Soft rot of asaparagus, therefore, can be reduced in two ways, in addition to maintaining proper temperatures: (1) By exposing the spears to high CO_2 atmospheres and (2) by shipping only spears with tightly closed tips. The first procedure still needs to be proved under commercial conditions; the second, however, can be used by any shipper, now.

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